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Chief, Office of Naval Research
Department of the Navy
Washington 25, D.C.

Attention: Code 414,   STAT

Subject: Application of Perceptron
Concepts to Photo-Interpretation

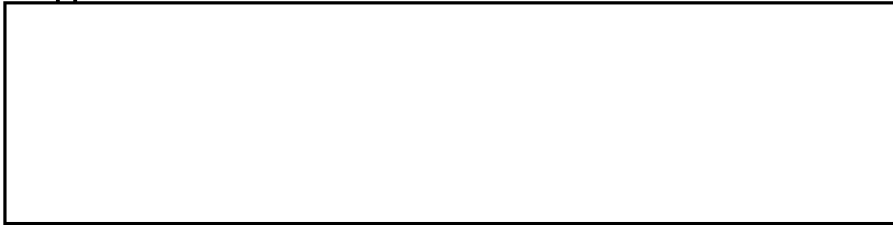Enclosure: Seven Copies of Letter Report No. 26

Dear Sir:

          We are enclosing nine copies of Letter Report No. 26
covering our technical progress under Contract   during   STAT
March 1964.

          Of the contract estimated cost as amended by Modification #6
amounting t[   ]we have expended[   ]as of 1 April 1964, leaving   STAT
a balance of[   ]In terms of cumulative labor and indirect costs   STAT
under the contract, the following is a summary as of 1 April 1964:
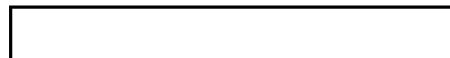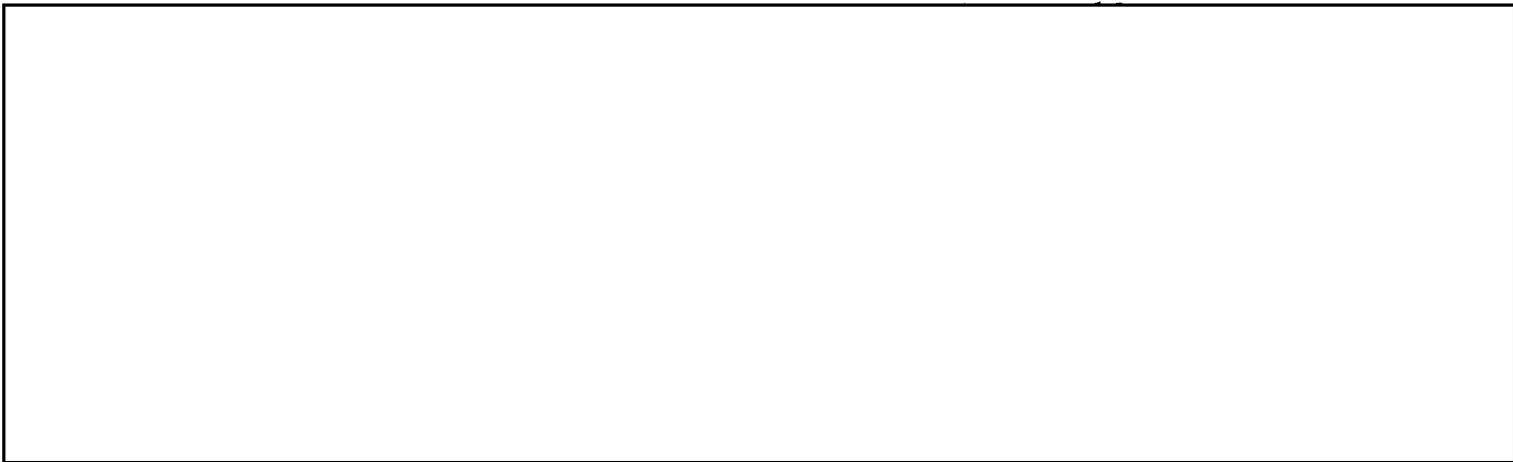
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Letter Report No. 26

Investigation of Perceptron Applicability to

Photo Interpretation

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Monthly Letter Report

for the month of March 1964

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1.0 INTRODUCTION

Project PICS is an investigation of the applicability of perceptrons to automation of certain parts of the photo interpretation task. Particular emphasis is placed on area and object recognition based upon properties derived from two-dimensional power spectra. Accordingly, effort is centered in the following major areas:

1) Theoretical and experimental evaluation of the properties which can be derived by optical spatial filtering.

2) Design and implementation of a recognition system based upon such properties.

3) Design of optical-electronic spatial filtering equipment.

4) Research based upon ideas whose immediate applicability cannot be stated, but of potential long-term benefit.

2.0 ACTIVITY AND ACCOMPLISHMENTS DURING MARCH 1964

2.1 Property Evaluation

Sufficient experimental evidence has been obtained, using the Mark III Spatial Filter Recognition Apparatus described in previous reports, to confirm that frequency plane filters can be used to detect line structure in an object transparency. No numerical evaluation of required line density for detection of culture is yet available, and photographic evidence was obtained too late for inclusion in this report. Certain experimental difficulties are discussed in the next section.

2.2   Design of Optical Electronic Spatial Filtering Apparatus

At the present time, the development of the optical-electronic
spatial filter has progressed to the point where 35 mm. slides, either
synthetically generated or from actual photography, can be processed.
Segments of the slides which contain significant line structure appear as
outputs on an oscilloscope with their geographical locations preserved. The
system is being adjusted and improved using a number of test slides.

A fundamental limitation of the design now in use for experimental
purposes is the variation in average intensity of the light input to the spatial
filter. This results in a requirement for a dynamically adjusted threshold for
determining what level of spatial filter output is to be called "significant line
structure." There are two sources of variation:

a)   non-uniform intensity of the illuminating source across
        the object transparency and

b)   non-uniform density of the object transparency itself.

Several potential methods for correcting of this effect have
been suggested, including dynamic adjustment of the light source (impractical
with the current laser source), adjustment of the accelerating potentials of
the photo-multiplier detector (possible, but difficult because of the very high
voltage levels involved) and use of an automatic gain control in the signal
amplifier. For any such method, a small proportion of the light output of the
signal transparency is diverted for use as a control signal. The reflection
from one piece of glass placed at an angle in the beam has already been shown
to produce a sufficient signal for this purpose. The circuit details are now
being worked out.

2.3   Recognition Studies

Work now proceeding on an internally-funded project is reported
here because of its close relationship to the methods and objectives of Project
PICS. This work has as one objective, the design of recognition systems for
noisy but un-translated patterns, based upon prototype information and a
statistical description of the distortions and alternative inputs.

The method borrows the idea of random connections from the
perceptron, using the sums of randomly selected points as properties for

recognition. In the treatment of these sums the new method and the perceptron differ. Whereas the perceptron thresholds the sums to form a binary property vector, the new method uses the sums directly in a multi-dimensional non-linear statistical classification model. The parameters of this model are not derived from training cycles, but rather are computed from the known prototype description and the given statistical properties of the environment.

A single experiment has been performed as of this writing, with gratifying results. The test objects were the same 240 distorted images created from four aircraft prototypes, plus 480 other noisy objects, which have been used for so many PICS experiments. The system tested used one hundred properties, each the sum of forty randomly selected points. Over this sample only one error was made - a single distorted ellipse being classified as one of the aircraft.

This work is continuing, both experimentally and theoretically, and appears to have considerable promise.

3.0   PLANS FOR APRIL 1964

Continuing experiments with the Mark III apparatus are planned. This experimental work will terminate near the end of April.

No other major experimental or theoretical efforts are planned for the current contract period. What remains of the available time and money will be used to prepare a final report covering approximately the last two years' effort.

4.0   REPORTS

No reports other than the regular monthly letter report were due or issued during March.
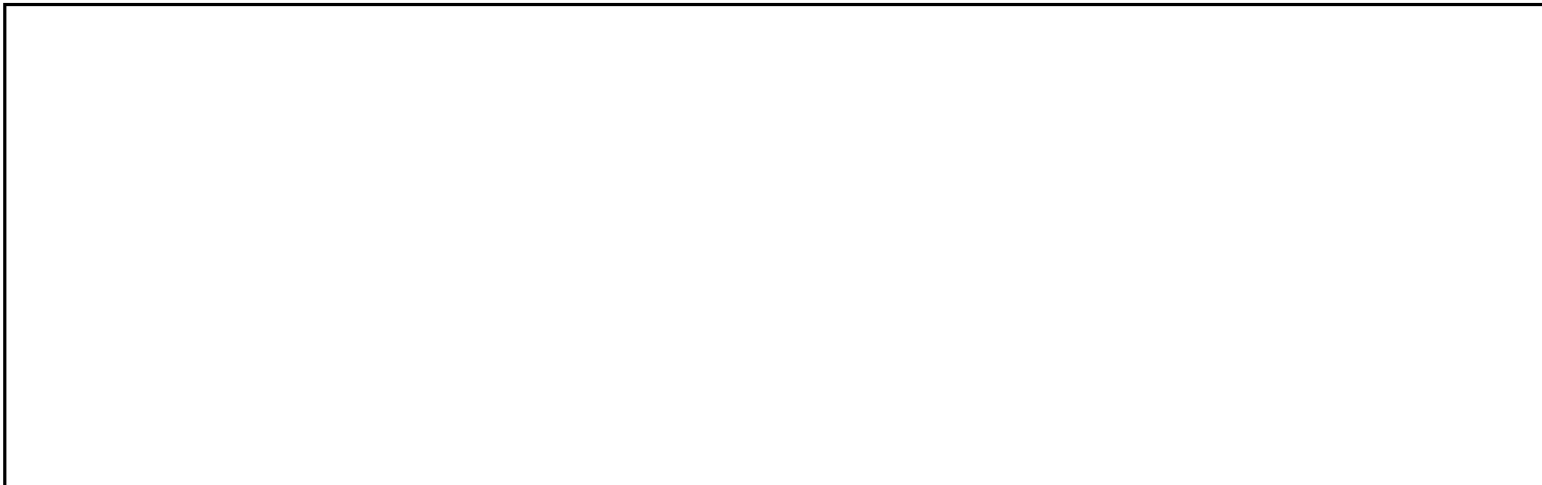
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